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Linear stability analysis of an ice sheet interacting with the ocean

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Abstract

A linear stability analysis of a two-dimensional flow of an isothermal ice sheet interacting with the ocean is considered. The set of boundary conditions determining motion of the grounding line is adopted to describe hydrostatic equilibrium of ice in water and a cubic dependence of the mass flow rate on ice thickness. The numerical analysis shows that the zero-growth (zero-eigenvalue) mode found for linear bed slopes and constant accumulation rates indeed determines neutral equilibrium and separates stable and unstable solutions. It is also argued that, provided some conditions of regularity of the solutions are satisfied, finding only one stable and one unstable solution would be enough to ascertain that the condition determining a zero eigenvalue also determines neutral equilibrium. This supports the intuitive understanding of ice-sheet stability: ice sheets are stable on bed slopes that ensure that the mass flow rate at the grounding line increases faster than the cumulative ice accumulation rate at the surface when the grounding line is perturbed; and ice sheets are unstable otherwise.

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